Experimental Study of Post-Tensioned Steel Trusses with Composite Slabs

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Summary

Test specimen No. 1, with a simple bridge span of 8534 mm, consisted of a 150 mm thick, high performance concrete deck in composition with a 600 mm deep steel truss. The composite system also included two12.7 mm tendons extending from end to end of the structure and draped at the third points above which equal test loads were applied. Prestressing levels of 460MPa, 690MPa and 920MPa provided mid-span pre-cambers of 1.8mm, 3.3mm and 4.4mm, respectively. For the extra 7.9% of the tendon cross sectional area as compared to the bottom chord cross sectional area, the post-tensioned composite truss resisted a maximum total load of 670kN which was 20.4% higher than the total load of 568kN in the case of a composite truss without prestressing. However, for similar specimen No. 2 with no composite slab, the use of post-tensioned tendons had no advantage on the steel non-composite truss because the specimen critically failed in the buckling mode of the top chord.

Keywords: post-tensioning; composite; steel truss; unbonded monostrand tendons; pre-camber.

1. Test Program

Truss A had a concrete composite deck and was subjected to prestress by the two tendons of 12.7 mm diameter DYWIDAG® monostrand tendons at three different prestressing levels of 460MPa (Test A1), 690MPa (Test A2) and 920MPa (Test A3). Test A4 was performed on the remnant of A# after the cables were cut and therefore no prestress existed. In test B1 the truss with no prestressing was tested. In test B2 tendons were stressed up to 460 Mpa and loads were applied up to ultimate.

2. Results and Discussion

Fig. 1: Post Tensioning of Truss A

Tests A1, A2, and A3 were performed at prestressing levels of 460MPa, 690MPa and 920MPa, respectively. This resulted in pre-cambers of 1.8 mm for A1, 3.3 mm for A2, and and 4.4mm for A3. In test A3 and A4 failure was in the ductile flexure mode. The stress in the bottom chord of the steel truss reached the yield strength while the top surface stress of the composite deck slab was less than the crushing strength. The yield load started at 550kN which corresponded to the yield deflection at 30mm. The load rams were continually operated to push the structure down until the bottom of the composite slab reached the top level of the lateral bracing frame at a deflection at 150mm. which was 5 times greater than the previous yield deflection.

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Fig. 2: Photograph of Test A3

The difference between test A3 and A4 was due to the post-tensioned tendons. Test A3 exhibited more ductile and was stronger than test A4. The maximum total load was 684 kN while the specimen of test A4 failed in the rupture mode of the bottom chord due to the ultimate tensile strain at the maximum load at 568kN. Adding the extra cross sectional area of 196mm^2 of the tendons to the bottom chord of 2480mm^2, or 7.9% of the sectional area, resulted in an increase in the total load capacity of 20.4%. ash shown in Fig. 3

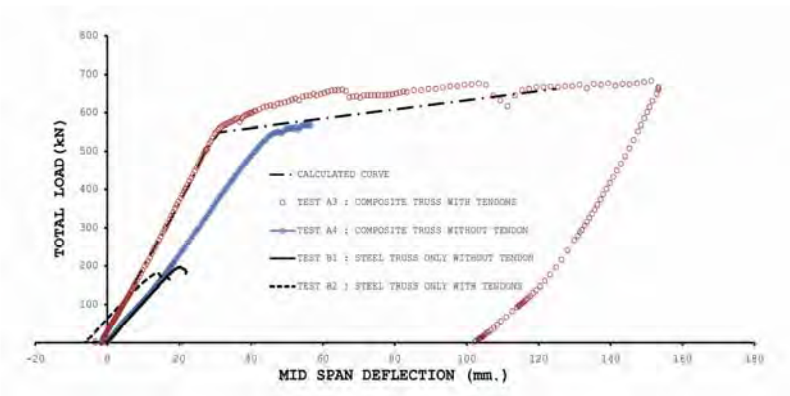

Fig. 3: Measured Load - Mid Span Deflection Curves

The calculated load-deflection from the application of the energy theorem, the principle of virtual work and the principle of superposition was verified by the experimental results especially for the elastic range. Tests B1 and B2 were performed on a steel truss only. The stiffness of the structure was greatly reduced compared to a comparative case of truss A. This was reflected by the lower slope of the load-deflection curve of test B1 and B2 as compared to the test of truss A. The failure of tests B1 and B2 were in the low total maximum load of 180kN to 190kN in the buckling mode of the top chord. In conclusion, the post-tensioned system cannot show any advantage to the structure because of the critical failure in the buckling mode.

3. Conclusions

The flexural capacity of the composite truss was significantly increased by using the post-tensioned technique. The ultimate load was increased 20.4 % by using prestressing tendons which were just 7.9 % of the cross sectional area of the bottom chord. The pre-camber can be controlled by adjusting the prestressing level. The local buckling of the truss members should be prevented when the prestressing level is increased. In order to utilize the advantages of the post-tensioned technique, the prestress tendons should be used to the composite truss of steel and concrete slab and not to the steel truss only. The concrete deck slab provides the effective lateral movement support for the steel top chord to prevent the structure failing in a lateral buckling mode.

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